Table of Contents

1 Introduction 8

2 Effects Characterization for Fish and Aquatic-phase Amphibians 9

2.1 Introduction to Fish and Aquatic-phase Amphibian Toxicity 9

2.2 Threshold Values for Fish and Aquatic-phase Amphibians 9

2.3 Summary Data Arrays for Fish 13

2.4 Lines of Evidence for Fish 15

2.4.1 Effects on Mortality of Fish and Aquatic-phase Amphibians 15

2.4.2 Sublethal Effects to Fish and Aquatic-phase Amphibians 31

2.5 Behavioral Effects on Fish 34

2.6 Sensory Effects in Fish 35

2.7 Population-level Effects for Fish and Aquatic-phase Amphibians 43

2.8 Effects on Fish and Aquatic-phase Amphibians Not Included in the Arrays 44

2.9 Concentrations Where No Effects Were Observed in Fish 45

2.10 Incident Reports for Fish and Aquatic-phase Amphibians 48

2.11 Summary of Effects to Fish and Aquatic-phase Amphibians 48

3 Effects Characterization for Aquatic Invertebrates 50

3.1 Introduction to Aquatic Invertebrate Toxicity 50

3.2 Threshold Values for Aquatic Invertebrates 50

3.3 Summary Data Arrays for Aquatic Invertebrates 56

3.4 Lines of Evidence for Aquatic Invertebrates 57

3.4.1 Effects on Mortality of Aquatic Invertebrates 57

3.4.2 Sublethal Effects to Aquatic Invertebrates 69

3.5 Effects to Aquatic Invertebrates Not Included in the Arrays 76

3.6 Concentrations Where No Effects Were Observed in Aquatic Invertebrate Studies 77

3.7 Incident Reports for Aquatic Invertebrates 78

3.8 Summary of Effects to Aquatic Invertebrates 78

4 Effects Characterization for Aquatic Plant 79

4.1 Introduction to Aquatic Plant Toxicity 79

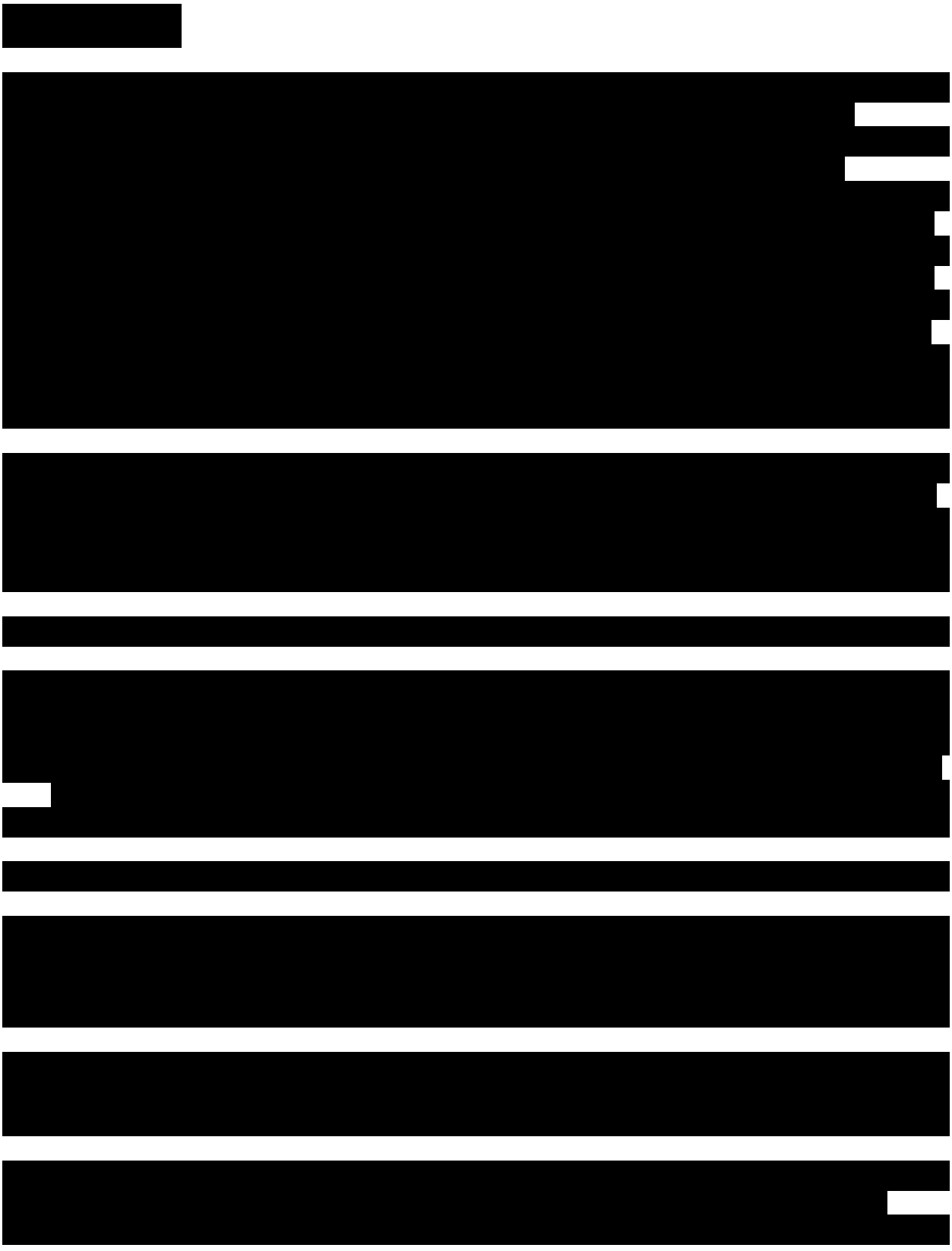
4.2 Threshold Values for Aquatic Plants 79

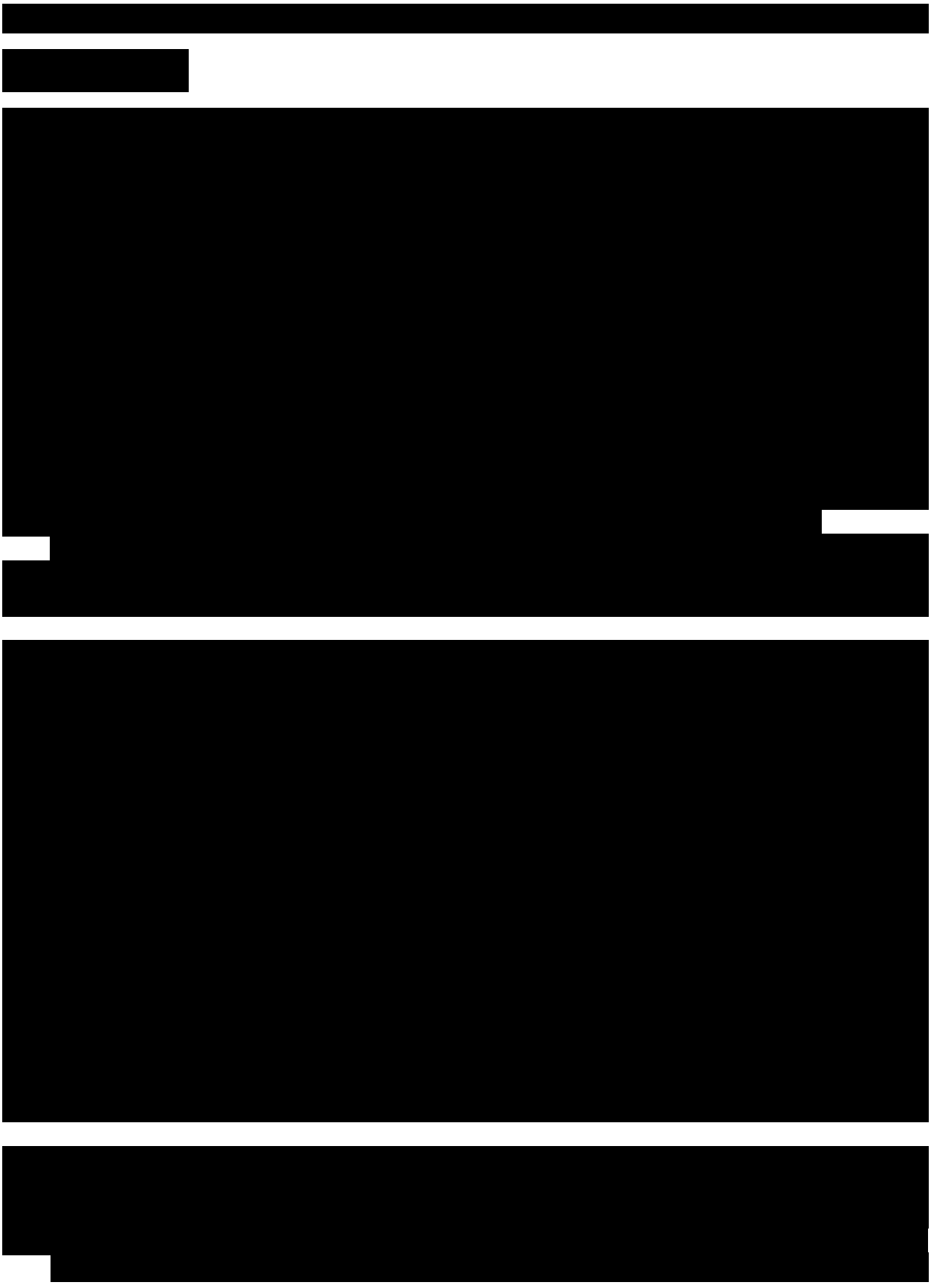
4.3 Summary Data Arrays for Aquatic Plants 81

4.4 Lines of Evidence for Aquatic Plants 82

4.4.1 Effects on Mortality of Aquatic Plants 82
4.4.2 Sublethal Effects to Aquatic Plants 82
4.4.3 Other Effects Reported for Aquatic Plants 85
4.4.4 Other Effects Reported for Vascular Aquatic Plants 86
4.4.5 Effects Reported for Non-Vascular Aquatic Plants (Comparison of Estuarine/Marine and Freshwater Species) 87
4.5 Effects to Aquatic Plants Not Included in the Arrays 87
4.6 Concentrations Where No Effects Were Observed in Aquatic Plant Studies 87
4.7 Incident Reports for Aquatic Plants 88
4.8 Summary of Effects to Aquatic Plants 88
5 Effects Characterization for Birds 90
5.1 Introduction to Bird Toxicity 90
5.2 Threshold Values for Birds 90
5.3 Summary Data Arrays for Birds 91
5.4 Lines of Evidence for Birds 95
5.4.1 Effects on Mortality of Birds 95
5.4.2 Sublethal Effects to Birds 97
5.4.3 Field and Semi-Field Data for Birds 101
5.5 Effects to Birds Not Included in the Arrays 102
5.5.1 Drinking water studies 102
5.5.2 Dermal studies 102
5.5.3 Inhalation studies 103
5.6 Concentrations Where No Effects Were Observed in Birds 103
5.7 Incident Reports for Birds 104
5.8 Summary of Effects to Birds 106
6 Effect Characterization to Reptiles 107
7 Effect Characterization to Terrestrial-phase Amphibians 108
8 Effects Characterization for Mammals 109
8.1 Introduction to Mammal Toxicity 109
8.2 Threshold Values for Mammals 109
8.3 Summary Data Arrays for Mammals 110
8.4 Lines of Evidence for Mammals 111
8.4.1 Effects on Mortality of Mammals 111

8.4.2 Sublethal Effects to Mammals 112
8.5 Effects to Mammals Not Included in the Arrays 119
8.5.1 Drinking water studies 119
8.5.2 Dermal exposure studies 119
8.5.3 Inhalation studies 120
8.5.4 Studies in Units of mass/area for Mammals 120
8.5.5 Other Reported Effects 121
8.6 Concentrations Where No Effects Were Observed in Mammals 121
8.7 Incident Reports for Mammals 122
8.8 Summary of Effects to Mammals 123
9 Effects Characterization for Terrestrial Invertebrates 124
9.1 Introduction to Terrestrial Invertebrate Toxicity 124
9.2 Threshold Values for Terrestrial Invertebrates 124
9.3 Summary Data Arrays for Terrestrial Invertebrates 127
9.4 Lines of Evidence for Terrestrial Invertebrates 130
9.4.1 Effects on Mortality of Terrestrial Invertebrates 130
9.4.2 Sublethal Effects to Terrestrial Invertebrates 142
9.5 Effects to Terrestrial Invertebrates Not Included in the Arrays 146
9.6 Concentrations Where No Effects Were Observed in Terrestrial Invertebrate Studies 147
9.7 Incident Reports for Terrestrial Invertebrates 150
9.8 Summary of Effects to Terrestrial Invertebrates 154
10 Effects Characterization for Terrestrial Plants 156
10.1 Introduction to Terrestrial Plant Toxicity 156
10.2 Threshold Values for Terrestrial Plants 156
10.3 Summary Data Arrays for Terrestrial Plants 159
10.4 Lines of Evidence for Terrestrial Plants 159
10.4.1 Effects to Terrestrial Plants 159
10.5 Effects to Terrestrial Plants Not Included in the Arrays 167
10.6 Concentrations Where No Effects Were Observed in Terrestrial Plant Studies 168
10.7 Incident Reports for Terrestrial Plants 170
10.8 Summary of Effects to Terrestrial Plants 176
11 References: 177





Effects Characterization

1 Introduction

Carbaryl acts by inhibiting cholinesterase activity, thereby preventing the natural breakdown of various cholines and ultimately causing the neuromuscular system to seize. This may lead to a series of various effects, which may culminate in death. Carbaryl is also used to thin fruit in orchards; its activity in the abscission of flower buds may be related to its structural similarity to plant auxins, such as α-naphthalene acetic acid. The effects of carbaryl have been studied extensively in many taxa, particularly in fish and aquatic and terrestrial invertebrates. Studies include acute and chronic laboratory studies with either technical grade (TGAI) or formulated carbaryl, and include both registrant-submitted and open literature studies. Discussions regarding toxicity to taxon from exposure to other chemical stressors of concern (*i.e.*, mixtures containing additional active ingredients besides carbaryl) and non-chemical stressors (*e.g.*, temperature) are discussed in **Sections 1.4.2.2.e** and **1.4.2.2.f** of the Problem Formulation. [redacted]

[redacted]

[redacted]

The toxicity data for each taxon are generally presented as summary data arrays developed using the Data Array Builder v.1.0. The arrays contain data from both laboratory and field experiments (*e.g.*, mesocosm). Data in these arrays are grouped by the type of effect (*e.g.,* behavior, reproduction, mortality), and present the range of LOAECs and NOAECs (NOAECs must have a corresponding LOAEC to be represented in array) for each effect type. Each of the effect types is discussed in further detail within each taxon effect characterization. For aquatic organisms, the data in the array represents exposure units of mg/L. For birds (and terrestrial-phase amphibians and reptiles) and mammals, the data is expressed in units of mg/kg-diet, mg/kg-body weight (bw), and/or lb a.i./acre. Toxicity data for terrestrial invertebrates are expressed as µg/bee, mg/kg-soil, mg/kg-bw, and lb a.i./acre. Data are expressed as lb a.i/acre for terrestrial plants. [redacted]

[redacted]

2 Effects Characterization for Fish and Aquatic-phase Amphibians

2.1 Introduction to Fish and Aquatic-phase Amphibian Toxicity

The effects of carbaryl have been studied extensively in fish. Acute and chronic studies for fish have been submitted by the registrant. It should be noted that EPA does not typically request toxicity studies for amphibians from pesticide registrants, but rather uses data on freshwater fish to represent potential effects to amphibians in the aquatic phase. [redacted]

[redacted]

[redacted]

[redacted]

[1] Last carbaryl refresh, April 2016

4 Effects Characterization for Aquatic Plant

4.1 Introduction to Aquatic Plant Toxicity

While carbaryl is an N-methyl carbamate insecticide used to control a broad range of insects and acts through inhibition of acetylcholinesterase, carbaryl is also used to thin fruit in orchards; its activity in the abscission of flower buds may be related to its structural similarity to plant auxins, such as α-naphthalene acetic acid [redacted]

8 Effects Characterization for Mammals

8.1 Introduction to Mammal Toxicity

The effects of carbaryl on mammals have been studied extensively. There are registrant submitted studies involving mammals, including acute and chronic laboratory studies with technical carbaryl.

[redacted]

9 Effects Characterization for Terrestrial Invertebrates

9.1 Introduction to Terrestrial Invertebrate Toxicity

Carbaryl, is an insecticide that acts through inhibition of acetylcholinesterase and is used to kill a broad range of insects and mites. As an insecticide, carbaryl's effects on terrestrial invertebrates has been well documented in the literature.

10 Effects Characterization for Terrestrial Plants

10.1 Introduction to Terrestrial Plant Toxicity

Carbaryl is also used to thin fruit in orchards; its activity in the abscission of flower buds may be related to its structural similarity to plant auxins, such as α-naphthalene acetic acid [redacted]